Major changes are underway for marine trunk piston engine oils (TPEOs). The use of distillate fuels in combination with the increased application of API Group II base oils, the demand for longer drain intervals and lower lubricant consumption all present significant technical challenges. Meeting the needs of the changing market requires new additive and formulating technology that meets the most demanding performance requirements.

Challenges with Group II

Group II base stocks have a number of benefits over Group I oils, including better oxidation control, improved Noack volatility and enhanced viscosity control. However, they also have lower solvency power compared to Group I.

This is an issue because the main challenge in using Group II base stocks in trunk piston engine oils is fuel contamination. Most fuels for four-stroke medium-speed engines contain asphaltenes that can enter the oil and agglomerate, forming black sludge in the engine.

Black sludge can lead to high levels of deposit formation that can result in piston deposits, choked oil galleries and oil starvation. Deposits on the piston undercrown are of particular concern because they act as insulators that prevent the lubricant from transferring heat away from the piston undercrown. This can quickly lead to corrosion on the piston.

Lubricants formulated in Group I base oils generally have excellent asphaltene handling capabilities. But Group II base oils, with their lower solvency power, are less able to handle asphaltenes. Therefore, new additive systems are required to ensure that lubricants formulated with these base stocks deliver the required level of engine cleanliness.

The Development Process

Developing reliable additive products for marine lubricants involves a rigorous two-step testing process. Elaborate laboratory bench testing is often the preferred first step, followed by selective evaluation in laboratory engine tests and field tests.

The first phase typically entails a Design of Experiments (DoE) procedure to determine the impact individual parameters on overall lubricant performance. Specific parameters are chosen to determine the best type of both detergent and dispersant and their optimal concentration ranges. Additionally, the type and concentration range of other components, such as wear, foam and rust inhibitors, is highly important to design an improved product. Additional boundary conditions include maximum base oil flexibility (API Group I and II) and reducing the use of brightstock as much as possible to produce an SAE 40 viscosity grade, thereby helping reduce base oil costs.

Good bench test procedures should correlate well with and closely predict field performance. However, good correlation is possible only for the specific operating conditions and formulating window for which the test was developed. Outside this window, the predictive value of bench tests becomes highly uncertain.

Therefore, it is difficult to predict performance in the field based solely on data obtained from laboratory bench tests. This can result in two undesired scenarios. First, it can produce a false positive, where the selected bench test candidate does not perform as well as expected in the field. Or, it can produce a false negative, where a candidate is unjustly discarded for further field evaluation based on poor bench test results.

Both scenarios can lead to unnecessary additional product development costs or lost opportunities for improved performance. Maximizing the chances for successfully developing the most cost-effective product requires careful interpretation of bench test data and confirmation of performance in laboratory engine test stands. Further validation of performance in field applications is critical and a key step in delivering innovative additive technology for marine
Putting the Process to the Test

Developing a new product for marine lubricants involves extensive statistical design of experiment studies, using both full and half factorial screening designs. Lab scale performance tests typically are run to select the most promising additive technology and formulating approaches. As an example, Oronite evaluated six candidate formulations in various bench tests.

As shown in the test results table, candidates 1 and 2 provided superior Hot Tube performance while candidates 2 through 6 provided improved Differential Scanning Calorimetry (DSC) and Modified IP-48 performance. The best candidates are further optimized using laboratory engine testing. Performance is also validated with several field application trials. Researchers compared candidates 1 and 2 to the low reference oil in a Caterpillar 1J field evaluation. No significant difference in piston cleanliness was noted; however, candidate 2 showed extremely good sludge control, an advantage that was not discovered in the bench tests.

Similarly, the Caterpillar 1J tests predict higher piston cleanliness performance from candidates 4 through 6 than the bench test data do. In summary, it is considered best practice to always include laboratory stand engine tests in product development test protocols, regardless of what the bench tests show. This approach allows for a more direct comparison of different lubricants under controlled conditions.

The data also supports the field test data obtained from the Caterpillar 3606 and demonstrates that bench tests do not fully predict the performance of the lubricant in the engine. Relying only on bench tests can introduce a risk of false positive and false negative results. Consequently, engine and field tests are critical for successful product development for TPEOs. They add tremendous value for customers, OEMs and end users, helping to ensure the performance they require.

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Wärtsilä 8L20 piston crown cleanliness for the low reference (left) and candidate 3 (right).

Engine Cleanliness Tests

AVL/Caterpillar 1J Piston Ratings

<table>
<thead>
<tr>
<th>Sample</th>
<th>Low Ref</th>
<th>Candidate 1</th>
<th>Candidate 2</th>
<th>Candidate 3</th>
<th>Candidate 4</th>
<th>Candidate 5</th>
<th>Candidate 6</th>
</tr>
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<tbody>
<tr>
<td>Base Oil</td>
<td>Group I</td>
<td>Group I</td>
<td>Group I</td>
<td>Group II</td>
<td>Group II</td>
<td>Group I</td>
<td>Group I</td>
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<td>119</td>
<td>101</td>
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</tr>
</tbody>
</table>

Source: Chevron Oronite
Our customers trust Chevron Oronite to help create value for their marine businesses. As a leader in marine lubricant additive technology, we leverage relationships with Original Equipment Manufacturers and monitor key industry trends in the marketplace. This enables us to deliver timely new products to meet evolving lubrication needs while complying with stringent emission regulations. To find out more about our latest MCL technology for low sulfur fuels, base oil flexibility, and how Oronite adds up for the Marine industry, please contact your local Oronite representative or visit www.oronitemarineadditives.com.